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23 October 2000

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**General Sigurd Frisvold**  
**Chief of Defence**

**Review of Forsvarets Forskningsinstitutt Division Electronics (FFIE)**

We enclose a brief report on our review of FFIE, which you commissioned earlier this year. The review was carried out in accordance with your tasking instructions and we are very grateful for the additional guidance which you gave to us during our meeting with you at FFI on 6 July 2000.

The review board undertook a detailed assessment of the work of FFIE, during the period 21 to 25 August 2000. This included presentations by FFIE researchers, discussions with FFI management and interviews with representatives of the military customers who fund projects at FFIE. The review board would like to acknowledge the contributions made by all of these personnel, who were very open, honest and constructive in their dealings with us.

The enclosed report presents a very positive view of the work at FFIE and the value obtained for Norwegian Defence. We have found some areas where we feel that even better results could be obtained and these are noted in the report, together with our recommendations. However, we were generally impressed by the standard of projects carried out by FFIE, the capabilities of the researchers and the dedication and commitment of all members of the Division.

All three members of the review board will, of course, be pleased to provide any additional details or clarification which you may require.

Review Board Members:

Dr Kjell Arne Ingebrigtsen  
Chairman

Dr Viv Roper

Dr Ole Petter Hakonsen

**EVALUATION OF  
FORSVARETS FORSKNINGSPOLITISKE RÅD  
DIVISION FOR ELECTRONICS (FFIE)**

**Prepared for Forsvarets Forskningspolitiske Råd**

**October 2000**

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## EVALUATION OF FFI DIVISION FOR ELECTRONICS (FFIE)

### 1 SUMMARY OF RECOMMENDATIONS

Below is a brief summary of recommendations resulting from the review. More extensive analyses and discussions leading to these recommendations are found in Chapter 5 below.

- FFIE has a very good understanding of the needs and requirements of their customers in their areas of research. This is the most significant strength of FFIE, and must be maintained or enhanced. FFIE should be engaged in the change in requirements caused by the current restructuring of Norwegian Defence.
- FFIE has a pure project organisation. Long project duration (average of 38 months) and large size (average 20 mill NOK) facilitate concentration and high accumulated value of the results. This organisation allows flexibility and adaptability to change, and is a strong asset for FFIE which should be maintained.
- FFIE should ensure that it maintains an adequate depth of capability in key areas of military technology. If there is an increased demand for FFIE's services in one particular area, say electronic warfare, without increased resources, FFIE should consider withdrawing from one of the current areas of research, rather than "salami-slicing" across all activities.
- With an increasing demand for studies and evaluations of systems FFIE should protect their assets by maintaining a strong emphasis on basic technology through the strategic program. Good work on systems level is contingent upon an expert knowledge of present and future limitations of systems components.
- FFIE's main customers interact with FFIE in different ways. The Navy tends to treat FFIE as a supplier of information which they have contracted FFIE to deliver. The Air Force work with FFIE more through team work. Although both ways seem to work, the review board believes that the team approach is more efficient and more effective.
- The technical quality of the work at FFIE is good across all areas. If measured from publications in the scientific literature the scientific quality is variable. A few of the researchers have a high profile, but most of the researchers are rather anonymous in these circles. The review board recommends that open publication in the scientific literature should be more actively encouraged.
- FFIE participates actively in the Nato activities, and with the university studies at Kjeller. A broader participation in international scientific communities is encouraged and will be stimulating for the researchers, and through personal contacts it will provide access to valuable informal information which otherwise is not accessed by FFIE.

- FFIE's work on IR warfare is of excellent quality. Since this is an area of growing military importance, the review board recommends continued programmes at least on the current level.
- FFIE researchers have strong loyalty and ties to their customers. This is good, but it must be balanced with loyalty and tie to FFI so that the necessary change of priorities is supported and initiated.
- FFIE should streamline their project management system, and adapt one tool across the division.
- FFIE should use their successes more actively to raise the pride and self esteem of their staff. They should be more open about career opportunities inside FFI and outside.

## **2 KICK OFF MEETINGS**

### **2.1 Meeting with the Chief of Defence, General Sigurd Frisvold**

The Review Board had the opportunity to meet with the Chief of Defence (COD) General Sigurd Frisvold at the start of the review.

The review board was informed about the recent proposal of a revised plan for The Norwegian Defence, and the possible implications on strategy and priorities. A plan which has a realistic basis in the expected budget together with the expected requirement for Norway to participate in international operations, will require much tougher priorities on the national defence. It is expected that Norway will play an important role in stabilizing the northern region. Together these requirements will have major impact upon the military structure for the future. The over riding requirement will be "value for money".

In this scenario the armed forces would need to develop their knowledge and expertise further in selected areas where they would rely on the assistance and support from FFI. Electronic warfare is an example of such an area.

The COD emphasized that the current review of FFIE was a normal "health check", and that he was in particular interested in an independent assessment of the quality of the work at the division.

## **2.2 Meeting with the Director General of FFI, Mr Nils Holme**

The Director General of FFI, Mr Nils Holme, opened the review with a brief presentation of FFI's organization, its funding, and the mechanism for prioritising the activities. Also presented was "Utdrag fra Vedtekter, Forsvarets Forskningspolitiske Råd" and, "Vedtekter for Forsvarets forskningsinstituttets virksomhet", both in Norwegian.

Mr Holme emphasised the mixed financing of FFI with about 40% basic funding, and 60% contract work. Forsvarets Forskningspolitiske Råd gives the strategic directions by prioritising the use of basic funds. He pointed out that the basic funding had diminished as a percentage of the activity over recent years. Mr Holme further emphasised the 100% project organization at FFI, and the importance of large projects in securing the quality of the work at FFI.

## **2.3 Meeting with Director, Division for Electronics, Dr Paul Narum**

The Director, Division for Electronics, Dr Paul Narum, presented the division's programmes to the Review Board. Accompanying the presentation was an overview of all projects at FFIE in the areas subject to the present review. Presented also were information about project funding, some personnel statistics, and his personal assessment of strengths and weaknesses. The presentation and the accompanying discussion was kept in an open and constructive atmosphere which made the subsequent investigations by the review board most efficient.

A total of 33 projects were presented for the review board. Of these 19 have a duration of 36 months or more, whereas only one project had less than 18 months duration. The total budget for the 33 projects is about 625 mill NOK. Of this about 250 mill NOK is from the basic strategic funding. The annual cost of the activity at the division is about 180 mill NOK. With about 180 employees, the spending per employee is about 1 mill NOK.

## **3 ORGANISATION OF THE REVIEW**

The review board decided to conduct the investigation by selecting certain projects for more in-depth review. It was decided to conduct the reviews as a project presentation by the FFI project manager followed by a discussion with the review board. The Director of Research responsible for the project was invited to participate in the session. In addition the review board asked to meet with the "customer" representative for the project. All customers agreed to meet with the board. The review board would like to compliment FFIE for organising the reviews in a very efficient way. The

project presentations given to the board were all of an excellent standard, being clear, comprehensive and well focused.

In addition it was thought desirable to meet with representatives on a strategic level of external customers and partners of FFIE. The review board is very pleased that Rear Admiral Jan Jæger, Commanding Officer of Naval Materiel Command, and Mr Tom Gerhardsen, Managing Director of Kongsberg Defence and Aerospace were available. The review board is grateful for their contributions.

In the selection of projects the board tried to cover several objectives. The breadth of the activity would be covered by at least one project from each of the Directors of Research. Together the projects should cover FFI's charter. It was important to select projects which would represent a continuing activity at FFI. Finally the use of the strategic funding was of particular importance. With this in mind the following projects were selected for detailed review:

1. P742 Tactical Communications Post 2010.  
This is the main communication project at FFIE. It is 2/3 financed by strategic funds.
2. P727/P795 New Escort Vessels/New Frigates  
The largest procurement contract ever for Norwegian Defence. The review board wished to understand FFI's contribution
3. P730 Naval Command and Control System  
The project is an investment into a new field at FFIE. It is 2/3 financed from strategic funds.
4. P694 Norwegian IR seeking anti ship missiles (NSM), with the connected projects P764 Detector for NSM (KDA project), and P713 Two Colour IR detectors.  
This activity is a 35 year old success story at FFI. It is the only field presented for review where FFI conducts full, vertically integrated, research from basic materials, through components, subsystems ,to full system integration. The Detector development is the largest current industrially financed project at FFIE.
5. P762 Electronic Warfare for The Royal Norwegian Air Force with the associated project P792 IR laser Countermeasure and Sensor Protection.  
Area of growing importance. Major engagement at FFIE by the Norwegian Air Force for many years.
6. P728 Passive and Active Systems for Air Surveillance, and its continuation:  
P805 Passive Sensors; Methods and Technology.  
Activity of growing international interest.

11 projects have been reviewed through this selection. Together they represent about 70% of the total planned cost of all projects listed. About 63% of the strategic funding planned are covered by the selected projects.

#### **4 FFIE PROJECT REVIEWS**

##### **4.1 Project P742: Communication Post 2010 (SIGVAT)**

Communication technology has been a strong activity at FFIE with a high scientific level. In the last 12 years researchers from FFI have published two text books on spread spectrum communications, a subject of key importance in secure and reliable communication. In the last 5 years several key researchers in communications have left FFI to explore other career opportunities.

Over the years FFI has contributed to the development of several different communication systems which have been industrialised by Norwegian defence industry. A significant export value has been created from these products.

SIGVAT was initiated 3 years ago from the assumption that future tactical communication would become an even more important component in international operations than it is today. A high level of expertise would be required by all nations participating in such operations. The expertise required will most likely involve utilisation and integration of commercial components to tailor a system to military needs. This approach, which will contribute to the reduction of systems cost, is strongly supported by the review board. It is expected that standards of some sort will be developed in order to facilitate interconnection of different systems. It is in the national interest to participate in the development of such standards. This requires a high level expertise which FFI has the ambition to cover.

The review board noted with surprise that the project had not been able to generate enthusiasm with FFIE's customers about satellite communication.

Over the last few years several key researchers in communications technology have left FFI to follow other career opportunities. SIGVAT has therefore been delayed, and much effort has gone into regeneration of the expertise and knowledge in military communication requirements.

The review board agrees with FFI's view on communications in future international operations and what type of challenges this will imply for the Norwegian armed forces participating in such operations. The need for keeping a high expertise at FFI is therefore supported. It is important, however, that SIGVAT be continued with a more



specific and concentrated project starting next year. SIGVAT is financed primarily from the strategic funds. In addition the different defence branches are engaged with shared financing. The review board recommends that the follow up project should have one primary customer who has ownership to the project.

The review board questioned why there is no communication project addressing Norway's more specific and challenging requirements in the northern region.

The review board was invited by the Director of research, Dr Torleiv Maseng to be informed about FFIE's initiative on "Internet Warfare", which was immediately accepted. The review board fully shares FFIE's view on the importance of being active in this field. The board suggested that FFIE should consider international collaboration with other partners on this subject, when appropriate.

#### **4.2 Project P727 and P795: New Escort Vessels/Frigates**

New frigates for the Navy is the largest procurement ever made for the Norwegian defence. FFI has assisted the Navy in the specification, analysis, and evaluation of the weapon systems proposed by the potential contractors. It was emphasised by FFI that substantial changes in requirements occurred during the procurement phase due to increased requirements from participation in international operations. The project has benefited from a rather wide range of expertise at FFI in radar systems, sonar systems, infrared systems, passive identification systems, and missile technology.

The Navy is pleased with FFI's contributions. FFI's assistance in the analysis of the anti air warfare system (AAW) was mentioned, but particularly valuable is the effort from FFI in developing a Norwegian anti submarine warfare system (ASW). This will give the Navy a better system than originally proposed by the contractor, and it will give Norwegian defence industry an opportunity to develop a new business of potentially significant value. There is general agreement that FFI has contributed significantly to obtain better frigates for the money available.

The review board emphasises the strategic importance of having a strong national capability in submarine technology, in particular those parts of the technology which are related to the specific problems and challenges of our fjords and coastal waters. A strong capability in military systems will also supplement and strengthen our civilian technology and industry.

FFI is further scheduled to participate in the validation of the performance of the frigates throughout the delivery phase. FFI will also assist in developing training program for operational personnel. Thus this will remain a significant activity for FFI in the future.

The Navy has not used FFI in this role before. They have expressed some unease at the contractual agreement whereby they are supposed to pay for time instead of paying for results at milestones.

It is recognised by all parties that FFI's involvement in the frigate projects is a more extensive contribution on the systems level than ever before. One reason is probably that the new frigates represent a major technology shift over earlier frigates, and as such it needed technical knowledge which was not readily available in the Navy. The review board has received similar comments on other projects as well. It is recommended that FFI continues to accept the challenge to assist the armed forces whenever a major technology shift requires such assistance. It is recognised that this means deep involvement in and knowledge of operational issues.

#### **4.3 Project P730: Naval Command and Control**

The current Norwegian system has been developed over time piece by piece, apparently without an overall strategy. The project initiated by FFI is based on the assumption that a coordinated strategy would give a system with better performance at substantially lower cost. At this level the project is financed primarily from FFI's strategic funding. The project is using an advisory board of 15 members representing all different stake holders in the existing system. The project has been somewhat delayed due to lack of personnel.

Research in this field is in its infancy internationally. The FFI group recently presented some of their work at an international conference, where they received a best paper award. Thus it is reason to believe that the scientific standard is good.

The Navy is satisfied with the results obtained at this point. They emphasise in particular the importance of understanding the cost associated with a continued evolution of the present system. There is reason to believe that the Navy would like the work to be continued when the present project is finished. It is possible that some of the recommendations from the current project will be followed even if the overall structure ends up to be different. However, the review board was concerned that there appeared to be a lack of "ownership" of the current programme by The Navy. Today the project exchanges information with other research groups and The Navy would probably encourage further international cooperation in this field, if such a proposal was made.

The review board has no reservations on the relevance of the project. There are questions regarding the scope and ambitions relative to the resources allocated. There may be several ways out of such a dilemma. It may be decided to add more resources, or the scope of the project could be reduced. An effective uplift in resources could be obtained by means of increased international cooperation.

It seems to the review board that this project should be linked to the proposed restructuring of the Norwegian defence. The change in the national structure as well as the requirements caused by international operations might influence the optimum solution with regards to operability and cost. To the extent that national security permits, it is recommended that international cooperation should be pursued at least on the subsystems level. This will serve to improve the relevance of the work. The ownership of the present project is too vague to ensure that the results will be seriously evaluated and used. Whatever form a continuation of this work takes, the activity needs to be firmly linked to a user with a genuine interest in the results. This may be obtained if a continued project is 100% contract financed by the user.

**4.4 Project P694: Norwegian IR Guided Anti Ship Missile (NSM)/  
Project P764: IR Detector for Anti Ship Missile/  
Project P713: Two Colour IR Detector**

The review board wanted to see the IR missile work together covered by the three projects listed above. In the NSM project FFIE acts on behalf of the Navy as a controller of the technical and operational performance of the NSM which is under development at Kongsberg Defence (KDA) for the Navy. This project is partly financed from FFI's strategic funding. The "IR detector" project is carried out under contract for KDA. The "Two colour detector" project is a basic materials project aimed at next generation IR seekers. It is 100% financed from strategic funding.

The NSM is a next generation IR seeking missile incorporating a totally new IR detector. The detector is essential for reaching the target specifications of the NSM. This activity at FFI is unique in the sense that it comprises a complete vertically integrated technical effort from basic materials through seeker construction to a complete sub-system. The review board therefore decided to review these activities together.

Organisationally it is a dilemma that FFI on one side assists the Navy in developing the specifications and monitoring the progress at KDA, and on the other side is a supplier to KDA of the most critical technology for the product. From a pure technical view, it is an advantage to have an in-depth understanding of systems implications to guide the trade offs that have to be done in the detector developments. FFI needs to be aware of the two different and conflicting roles, and strict project discipline has to be executed by all parties involved. Evidently the Navy has some concerns on these matters, but recognises the advantage of having an efficient and knowledgeable organisation undertaking the tasks.

The provision of a fully, vertically integrated technical activity is a strategic decision made by FFI. A significant part of FFI's strategic funding is spent to support this.

The Navy strongly endorses the value of having national control over the key detector technology. The review board is, however, not convinced that they would be willing to take full financial responsibility for the detector work at FFI.

The board understands and supports the strategic importance of FFI undertaking a significant activity in IR technology, not only for the NSM project, but also to understand in depth the strengths and weaknesses of IR detection in general. The board was informed that it is a growing technology for missile guidance, which has played a significant role in the more recent major international conflicts.

The best way to acquire in depth knowledge is to engage in technology research and product development. The combination of the three projects above is, therefore, an excellent tool also to understand IR warfare in general.

The review board therefore supports the IR work at FFI at least at the current level of effort. The current level of spending is well justified. The review board questioned whether KDA should be licensed to exploit FFIE technology in overseas sales. In this way, some royalty money could be returned to FFIE following any overseas sales of KDA equipment. This money could be reinvested in research on future military technology (to the benefit of the Ministry of Defence and Norwegian industry) and would increase the motivation of FFIE researchers.

The FFI work on IR materials using molecular beam epitaxial (MBE) deposition is of high quality. Although the work aims at supplying material for detector fabrication, it has produced scientific knowledge of broader value. The group rates itself as one out of three top international groups within their field. They enjoy laboratory facilities of high standard. Although the first NSM will not use MBE grown material, there is a significant performance upgrade potential for the NSM when it becomes available for commercial exploitation.

Perhaps the most impressive engineering work demonstrated to the review board was the IR seeker integration. It requires a broad range of technology know how. The review board noted that KDA is very pleased with the performance of the prototype seekers delivered by FFI in the NSM project. The intention is that KDA will manufacture the seekers once the prototype series has been delivered. It has not been decided whether KDA also should manufacture the detectors. The review board recommends that FFI and KDA find a practical way of cooperation on seekers as well as on detectors which ensures the best quality in the final product and which minimises duplication of expertise. Clearly, in the event of a need for large quantities of detectors, manufacturing at FFIE's premises is not necessarily the best solution. The Navy is satisfied with FFI's contributions in the NSM system project. It is emphasised that the NSM is unique with no competitive weapon available. FFI is

honoured by the Navy for its contribution in initiating the project as well as developing the specifications.

In the Frigate project, FFI participated in developing the functional specifications, and left it to the bidders to propose implementations. In the NSM project FFI must have been much more involved in suggesting the implementation. There are potential political problems for FFI in this position and it is important that FFI is seen to behave with integrity, always continuing to do what is best for their military customers.

#### **4.5 Electronic Warfare for The Air Force and IR Laser Counter Measures and Sensor Protection**

FFI has been working with the Air Force on electronic warfare (EW) since 1975. The work has been concentrated on electronic counter measures (ECM) against tracking radars in surface to air missile systems, and anti air artillery systems. The work is highly regarded in Nato and in a recent comparative test of systems from several Nato countries, a FFI system came out on second place.

Self protecting ECM in air to air scenarios will be more important for the Norwegian air force in the future partly due to participation in international operations. A relatively new activity in the group is protection against IR seeking missiles. With the increased use of such missiles, the relevance is indisputable. The benefit from this work on the NSM project is obvious.

Over the years the FFI group has participated in the development of several generations of jamming equipment for the Norwegian Air Force. A tight relationship based on mutual trust and dependence has developed. The cooperation has the character of a team work rather than a customer/ vendor relationship.

The nature of this work does not readily lend itself to publications in the open literature nor to international cooperation. However, as expressed by one of the researchers: "In this field you must have something to give if you shall receive anything.

The Air Force is pleased with the activity at FFI. The group appears to have a good standing in Nato circles. And as mentioned already, in competitive trials with allied groups they perform very well. The review board fully endorses the effort started on IR frequencies. It will be a valuable supplement to the work on IR missiles.

The increased use of IR warfare in the infrared spectral region is the basis for this project. It aims at studies of IR radiation sources for jamming purposes, and for developing protection of IR sensors against such jammers. The relevance of the

project is indisputable. Part of this project is an international (EUCLID) project involving Thomson CSF from France, and SIMRAD Optronics from Norway.

This work covers a wide scope in lasers and techniques for IR countermeasures and in the protection of military systems against the effects of lasers. The laser work is of a high standard and is well founded on existing laser expertise at FFIE. The topics researched within sensor protection will need to be carefully prioritised, as the resources available will not be adequate to cover all options. Full use should be made of existing, published information and the use of international exchanges or joint programmes with nations possessing expertise in sensor protection is strongly encouraged.

This group at FFI holds a high scientific profile and they have a high publication rate in peer-reviewed international journals.

The technical results of the laser work presented to the review board are of good international standard. Particularly impressive was the simulation model for lasers, which matched the experimental work exceptionally well.

#### **4.6 Passive and Active Systems for Air Surveillance and Passive Sensors; Methods and Technology**

The latter project is a continuation of the first, starting this year. This area has enjoyed growing attention particularly after the "Gulf War". The Air Force emphasises their interest by growing financial support to the activity at FFI.

It is obvious that activity in this area is subject to secrecy, and little work is published in the open literature. It is difficult therefore to assess the scientific quality on a comparative basis. However the group at FFI has shown very good productivity in a relatively short time. They are very enthusiastic about their work. There is genuine interest shown by the Air Force in this project and the review board believes that continued work in this area would be a good investment.

### **5 OBSERVATIONS, ANALYSIS, AND COMMENTS**

There are few objective measurements for quality, relevance, and "value for money" in research. The main reason for this is that the results from applied research show up much later, and are usually apparent to the users of the results. The results of the on going research at the Norwegian Defence Research Establishment, Division for Electronics (FFIE) will therefore show up many years from now in the Norwegian defence and in Norwegian defence industry. The review of the present activity at

FFIE was therefore based upon the experience and reference background of the members of the review board.

The review board decided to examine a set of parameters which are believed to impact the performance of FFIE:

- Scope of work
- Assessment by the "customers"
- Technical and scientific quality
- Facilities and tools of research
- Collaborations
- Personnel and resources
- Organisation
- Use of strategic funding
- Innovations
- IR technology

### **5.1 Scope of Work**

Scope of the work is directly related to its relevance. Given the constraints of finance, are the priorities right, is the concentration good enough to secure quality, and is the adaptation to change in requirements good enough?

Establishing top quality research expertise in a specific field is hard work and it takes years to reach there. Thus there is sometimes resistance to major changes among individual researchers. Although understandable, this is in many ways a paradox since researchers are expected to create change through their own work. However, changes in the external requirements may require other priorities. The flexibility of a research organisation determines its ability to react to new requirements. Thus, FFIE should also be judged on its capability to accommodate to change.

FFIE is well positioned to accommodate and adapt to the technical evolution taking place within its specialities. A result of this evolution is the increased complexity of technical systems. Perhaps over-simplified this may be phrased: "Whereas we earlier always needed more data to make a decision, we now struggle to make a right decision in a jungle of more or less reliable and unreliable data made available to us."

There are several implications of this. It puts more demands on the user of the complex system in procurement as well as in operations.

FFIE has experienced a tendency that more of the requests for its services are in systems studies. The question has been raised whether this is caused by the change in financing of FFI with more of the funding being contracted, or whether it is caused by a reduction of the armed forces own technical expertise. The review board would like to add the following comments. Whatever the reason, there has to be a match between FFIE and its customers to ensure that the results of FFIE's work are not lost and are fully utilised. Thus FFIE has to accommodate to their customers needs when it comes to the contracted work. If there is a pressure towards more short term assistance or consultancy work, it is even more important that the use and size of the strategic funded projects at FFIE should be shielded and invested for high risk, basic technology development. The borderline between FFIE's work and the work for their prime customers should always be monitored and subject to audits. There will be a major problem if a gap develops whereby FFIE becomes more detached from their customers. There will also be a significant loss to all parties if FFIE's ability to make assessment of leading edge technology developments becomes eroded. Maintaining the correct balance between technology competence and focused, shorter term military projects is of vital importance in maximising the value of FFIE's work.

The imminent reorganisation and restructuring of the defence in Norway should engage FFI and FFIE. FFIE's initiative to study the Naval Command and Control system in Norway is an example of an involvement which may be of value in this connection. If FFIE is to undertake more work of this kind without additional funding, something else will have to go. It is the opinion of the review board that projects like the Naval C&C should be carried out as a team work between FFI and the contracting organisation, and that it should be funded by contract and not from FFI's strategic funding.

All work on systems depend on a profound understanding of the capabilities and limitations of the components which comprise the system.

FFIE will face a growing dilemma in prioritising systems studies against component work. This was stated by one FFIE researcher during the interview: "We have to work with real hardware to understand the limitations on the systems." Without increased funding this development may ultimately limit FFIE's involvement to even fewer systems.

The FFIE activities subject to the present review are grouped in the following main categories.

- Command and Control



- Communications
- Electronic Warfare
- Infrared weapons technology
- Radar
- Space
- Unmanned Aerial Vehicles (UAV)
- Frigates
- Norwegian IR seeking anti ship missiles (NSM)

The last two areas are directly connected to procurements by the Norwegian defence. The present review has not specifically covered projects from the space and the UAV activities.

In many of the areas there has been continuous research conducted over a long period at FFIE. The definition of new projects has been a natural consequence of the evolution of the technology. A close cooperation with partners within the Norwegian defence forces has secured the relevance of the projects.

Command and control, UAV, and certain methods in electronic warfare are new areas of research, initiated over the last five years or so. Altogether they represent about 20 % of the totality of projects presented for the review board. In the opinion of the review board this shows a satisfactory capability by FFIE to adapt to major technology opportunities (UAV), and to the change in requirements of the external partners (C&C and EW).

In conclusion we believe that FFIE is well connected to the needs of their prime customers in the Norwegian Defence. We believe that there will be requests for FFIE to carry out even more systems related projects and this will require complex decisions on priorities to be taken. The review board recommends that adequate steps are taken to protect the current level of strategic research funding, and to focus this funding on enhancing basic technological capabilities.

## **5.2 Assessment by the Customers**

Even if FFI's charter emphasises contributions to the national scientific and technical environment, the primary objective is to support and create value to the Norwegian Defence. The various branches of the armed forces, the Defence Staff, and the Ministry of Defence represent about 50% of FFIE's activity through contract work.

35% comes from FFI's strategic funding, which is also from the defence budget, and the last 15% is from industry and other sources. Over the last few years the Navy through the Frigate procurement and the NSM has been a large user of FFIE's services. The Air Force seems to be a more stable user of FFIE over the years on EW issues and IR missile technology. We understand that services for the Defence Staff has been growing.

FFIE's way of cooperating with The Navy and The Air Force are quite different. The Navy looks upon FFIE as a vendor of services and technology, and they work with FFI when national security requires, and otherwise only if FFI has the best offer. In most respects they prefer to treat FFI as a demanding customer should do, but admit that they have not always been good in this role. The relationship with The Air Force is quite different. FFIE is here treated as an "insider", a partner in technical development. It was interesting to note that one Navy officer also commented: "When we work together as a team we get excellent results". Although both ways seem to work, the panel believes that the most valuable and cost effective results were generally produced where FFIE scientists and their military customers worked essentially as a team, collaborating closely in the planning and inception of projects and where this approach is continued throughout the life of the project.

FFIE has a contract with Kongsberg Defence on IR seeker development. This is of the customer/supplier type.

Several FFIE customers emphasise the importance of "knowing FFI" to obtain good results. During the conversations it became clearer that what was more important was to know and understand the partner within each project- or in other words- communications. One reason for these comments could be that project officers on the customer side change quite often; typically there are two or more project managers on the customer side during a project period. In order to improve upon this it was suggested by one of the officers interviewed that the Navy should perhaps have one person specifically assigned to follow the FFI contracts.

Tom Gerhardsen, Managing Director of Kongsberg Defence (KDA) is very positive in his comments on FFIE's work. He stated that "they deliver good quality work on time, and their researchers are responsible and reliable". He emphasised FFIE's role as an adviser to the defence on systems specifications. For KDA this was more important than the actual IR seeker development. He would like to see more consolidation of capabilities at FFIE and expressed some concerns about the broad scope of their current activities.

The review board did not meet with one unhappy FFIE customer. They were all generally positive to FFIE's performance. They gave the impression of being

constructively critical, and have given comments and suggestions in areas where they felt that improvements could be obtained.

Comments quoted from the interviews are:

- They deliver what they have promised on time.
- We can always rely on FFI. FFI is never wrong.
- They hold a good international level. The advice we get often put us at an advantage in discussions with peers from other nations.
- They did a good job on the weapon subsystems in the Frigate procurement. Excellent on the ASW (Anti Submarine Warfare) system. More variable on other subsystems.
- When FFI and the Navy work together as one team we get excellent results.

And the most critical:

- FFI is variable. It depends on the individuals. Sometimes their recommendations are too vague to be of any use.
- Sometimes FFI act politically. Perhaps they struggle with their dual role of giving the best advice to the defence and promoting Norwegian defence industry.

In a couple of cases the review board experienced a difference in perception between the FFI researchers and their customers on the most important result of FFIE's project. This is unfortunate and not necessary. We therefore recommend that a more formal and extensive "customer satisfaction" procedure be implemented and enforced. Since the projects last several years we recommend a less rigorous review at each milestone so that necessary improvements can be put into effect before it is too late in each project. It is important that the complete project staff at FFI meet with the customer representative at such reviews.

We recommend that quality, relevance, and value to the customer be addressed in all project reviews, and also that the question "Could this have been done better?" is asked. Even if no firm answers can be given, it will have an educational effect to discuss it in the project team. Over time it will improve the FFIE focus on these issues.

It is important that a clear project ownership is established on the customer side. Multiclient work seems to give results of less value and/or have a larger chance of being "filed" rather than acted upon.

### **5.3 Technical and Scientific Quality**

New scientific knowledge is first available in scientific circles. The world scientific community also has a peer review system which is the only known system to secure scientific quality and relevance. Being an active, recognised member of the scientific community therefore gives access to scientific data before it becomes public, and it gives access to information which never get published. To become member of these circles scientific quality and productivity have to be demonstrated. This is accomplished through open publications, conference papers, and networking with the world scientific community. Researchers from defence research institutions do participate in the open scientific literature on subjects of general interest. In addition Nato is engaged in organising scientific meetings and seminars on more specialised "hot" scientific subjects.

By its nature much of defence research is of a confidential nature and cannot be made available for open publication. This applies more strongly to systems related studies, but opportunities do exist for open publications even in this topic area. Some of the FFIE research is published in this "systems" literature.

The review board interviewed FFIE's customers about their views on open scientific publications. The response has been from neutral to positive. Thus it is concluded that participation in the scientific community is a priority issue which can be determined by FFI itself. It is the opinion of the review board that FFIE underestimate the scientific value of much of their work and should be actively encouraged to publish more, where security issues allow. It was a pleasure to learn that the Naval C&C project has resulted in a publication which was recently honoured with a best publication award. Greater exposure of FFI capabilities achieved via publication would also benefit FFI directly by enhancing its world standing in the perception of other world scientists and may lead to additional, beneficial international collaborations.

From the scientific citation index we observe that FFIE has some highly recognised scientist in geophysics, lasers and remote sensing. However, on a broader view, more FFIE researchers should participate actively in the technical scientific community. We believe this will secure the quality of the work in general, and it will be motivating for the individual researcher to get more international exposure.

For this to happen, it has to be emphasised and prioritised by the management of FFI.

### **5.4 Facilities and Tools of Research**

The research facilities demonstrated to the review board are of good international standard. Particularly impressive are the facilities for fabrication and characterisation

of IR materials and components. The review board believes that the laboratory is well equipped to address the next generation IR detector and laser technology. This was confirmed by the researchers interviewed on the subject.

The committee was somewhat surprised to learn that there is a lack of adequate project management tools. For historical reasons there are different systems in use by different project managers.

The review board recommends that a standard project management system be introduced. It will make communications with customers on project administrative issues simpler. It will help to professionalise the project manager role, and make their life easier. And it will be a tool which perhaps helps management to control "value for money" on a more detailed level.

### **5.5 Collaborations**

The Navy and the Air Force compliment FFIE for their collaboration skills in team projects. FFIE also has extensive participation in various Nato assignments on different levels in technology and research. This ensures adequate updating on military technology in general through informal exchange of information. More formalised collaborations take place such as Anglo Netherlands Norwegian Collaborative Projects (ANNCP), EUCLID projects under EU, and bilateral agreements with USA. Currently the division is represented on 6 management level groups, and in more than 20 project working groups.

An extensive collaboration exists with the University of Oslo through the technological studies at Kjeller (UNIK). 4 researchers from the division have associated professor (Professor II) or lecturer (Amanuensis II) positions at this location (3), and with the University of Lund in Sweden (1). 1 full professor at UNIK has an associate researcher position at FFIE. FFIE researchers teach 14 different subjects at UNIK. Currently FFIE researchers have advisory responsibility for 4 doctor students and 11 master students at UNIK and other universities. The review board recognises the importance of this for FFIE as well as for the universities involved, and would encourage the continuation of this activity at least on the present level. Not only does it provide FFIE with an excellent recruiting channel and an academic stimulation for the activity at FFIE, but it is also valuable to the university research programmes and hence to Norwegian society in general.

### **5.6 Personnel and Resources**

FFIE spends about 1 mill NOK per employee each year. This is comparable to R&D spending in similar institutions in Norway and in Norwegian industry. It was

confirmed to the review board that once a project had been approved, the resources allocated were normally adequate. Delays to projects were seldom caused by lack of money, and were generally caused by a shortage of available personnel. With increasing constraints on budgets, it is often easy to reduce project funding, and the FFI management deserves recognition for maintaining adequate funding to the research projects.

FFIE has a turnover of personnel of 6% per year. Most of this is probably among scientists, making scientist turnover perhaps 10%. This is not exceptionally high with the demand for personnel of this category in Norway today. We understand that most of the scientists leaving are relatively young people with 5 to 10 year experience at FFI. This is normal also in other R&D work. However, whereas people leaving other organisations often go to work for a competitor, perhaps move to other functions such as management or marketing within the same organisation, or move to work for an earlier customer, this is different with FFI. Almost no one leaving FFIE goes to work in the Norwegian defence nor in Nato. We have also been told that only 50% of those leaving transfer with FFIE projects to work in the defence industry. Thus, many people leaving FFIE transfer to other branches of the society, and their accumulated expertise on defence technology is lost.

It will be of great value for the society if one could find means which stimulated more highly qualified technical people to stay with the Norwegian Defence, even if it is in a different role.

We believe that FFIE should continue to motivate people with intellectually challenging jobs. They should make clear the career opportunities inside FFI, offer attractive scholarships abroad and job opportunities in Nato. Most people are more comfortable in their work if they know they have alternatives even if they will never use them. FFIE should be shown as an attractive and lively place to work, which brings benefits to Norwegian society in general.

## **5.7 Organisation**

FFI has a pure project organisation. The review board has been presented 33 projects for review. The list of active projects is probably smaller since some of the projects have been completed this calendar year, and followed by new projects which are also on the list. The average lifetime of a project is a little over three years, thus there are about 10 new projects generated every year. There is only one project on the list with less than 18 months duration. The size of the projects varies, from a few million NOK each to over 50 million NOK for the largest.

The review board is much in favour of this organisation. The assets of an R&D organisation are the accumulated knowledge and its capability to facilitate change.

The large size and the long duration of projects at FFIE ensures accumulation of knowledge. A project organisation by its nature initiates change when there is no automatic prolongation into new projects. The review board believes that the project organisation is perhaps the most valuable strength of FFIE, securing quality and relevance of the work.

The various projects are supervised by four (temporarily five) Directors of Research. Their scientific background determines to a large extent the nature of the projects they supervise. This has led the review board to believe that the Directors of Research are the nucleus in the creation of new activities and new projects. Although this seems to work well, we would encourage the management to examine the current system for project generation to see if the full creative potential in the organisation is being exploited. The review panel believes that all FFI scientists should formally be included in the generation of new ideas for strategic projects. This could be accomplished by means of annual request for outline proposals, which could then be considered by an internal review process.

With a pure project organisation it is important to have measures that are common to the total organisation, in this case FFIE, to bind together the organisation outside the individual projects. We would recommend that FFIE on the division level generate certain goal and objectives on an annual basis, for example along the lines of quality, relevance, and "value for money". In this way FFIE, in addition to the individual projects, would have a reason to celebrate the accomplishments of the goals.

On the project side we would suggest that the management makes more use of celebrations to promote staff motivation, including invitations to customers to recognise any project break through. The review board did not meet with any demotivated employee during the reviews, so there is no specific reason to bring up this issue. There was however a notable feeling of differences in the attitude and perhaps also internal culture of the various project groups. This leads us to suggest that perhaps the loyalty to the division should be strengthened.

In one of the interviews with customers the review board received a clear feedback about culture differences between FFI divisions, which has been reported separately to the Director of FFI. It is a matter for senior FFI management to ensure that FFI presents a unified and co-ordinated external face to military customers.

## **5.8 Use of Strategic Funding**

About 35% of FFIE's funding is of a strategic nature. It covers basic research and strategic programs and represents FFIE's investments for the future. It will normally be expected that a project under the strategic program subsequently turns into a contract project. However this is also where FFIE can take risks. It is a management

issue to balance the risk against safer preparation for future contract income. Most of the success stories which FFIE is known for outside military circles have started as strategic projects. The use of strategic funding at FFI (and FFIE) is a responsibility of "Forsvarets Forskningspolitiske Råd".

Over the years FFI's strategic funding has been reduced, and FFI's management has raised a voice of concern over this. Because of this the review committee decided to examine the use of the strategic funding at FFIE, and express an opinion on the subject.

Almost half is spent on three projects which all are aimed at establishing new activities. UAV (unmanned aerial vehicle) is a high risk project 100% financed by FFI. It is a study of new missile weapon concepts which ultimately may lead to later product development. Communication after 2010 (SIGVAT) is in many ways a rebuilding of the communication expertise at FFI after significant personnel turn-over during the last five years. The project will be finished early next year with the intent to be continued into a more well defined project target. Naval Command and Control has the objective of building expertise in system requirements. The technical risk with this project is considered low by the review board. The main risk is customer acceptance on the organisational level. Further progress in this direction must be achieved by the project team, with active participation on the military operational side.

A substantial part of the strategic funding is spent on IR materials and components. IR warfare is of growing importance, and FFIE is engaged in this more generally in addition to the IR missile development for the Navy. With the growth of this technology it is fortunate that FFIE has a basic technology program and substantial accumulated knowledge which enable assessment of the potentials and limitations of the IR warfare. About 20% of the strategic funding is shared between 16 different projects. Most of these projects are partly funded by external sources. We assume that the strategic money is spent on high risk elements which may have significant implications if they are successful.

15% of the strategic funding at FFIE is spent on the development of the new antiship missile project for the Navy. Because of the size of the sum we assume this funding has been subject to thorough review. We would normally have expected that a product development like this would be more fully supported by contract finance.

It is natural to expect that FFI will be under pressure to assist the armed forces with more short term problems during the restructuring of the Norwegian Defence. Under such circumstances the review board recommends that the strategic funding be reserved for investments into basic technology.



## 5.9 Innovations

Innovations are natural results of technical and scientific research. Although there must be substantial innovation within the projects at FFIE the review board was surprised to see that FFIE does not protect their innovative work by patents. We understand that this may not be the prime objective of Norwegian defence programs, but patent protection may benefit defence procurement and could certainly be of value for Norwegian industrial partners of FFI. Royalty returns from FFIE patents could also provide a significant future income to FFIE, which could be reinvested in new basic research (with benefits to military applications and possibly to generate further, patentable technology). The review panel that FFIE has not fully exploited the potential of patent rights and licensing. It is recommend that FFI looks into this issue.

## 5.10 IR Technology

IR technology research and development represents a significant part of FFIE' activity. The review board therefore decided to give separate comments on this. Work in this field was started almost 40 years ago at FFIE, which was one of the pioneering organisations in the exploitation of this technology. It is well known that this has led to the Penguin missile, a significant product for Norwegian defence industry. FFI has continued to support this technology over the years and participated with evolution of the technology. For the next generation missiles there will be an IR technology shift with more advanced missile guidance as a result. FFIE is in the forefront of this technology. This also puts FFI in a rather unique situation when it comes to counter measures against IR weapons.

The review board feels that the current level of investment is adequate to the goals and ambitions established. Although this activity takes a large part of the investments at FFIE, it is a good investment into an area which will have growing military importance, and where the investment can give Norway an advantage for its defence as well as for its defence industry.

## 6 INTERVIEWS

The interviews on project activities at FFIE were a most valuable exercise to the review board. This made our investigations most enlightening and efficient. We are therefore most grateful to the people who could take the time to share their knowledge of and involvement with FFIE with the review board.

These were: From Kongsberg Defence, Mr Tom Gerhardsen and Mr Trygve Strand.

From the Navy, Rear Admiral Jan Jæger, Captein Bjørn Krohn, Commander SG Jan W Dahl, Commander Hjalmar Johansen.

From the Air Force, Brig. Anders Thorheim, LieutCol Morten Hansen.

And from FFIE, Svein Haavik, Torleiv Maseng, Arne Cato Jenssen, Johan Aas, Karsten Bråthen, Vidar Andersen, Stian Løvold, Rolf Hedemark, Harald Hovland, Knut Stenersen, Emil Brodersen, Egil Bingen, Svein Erik Hamran, Hans Øhra.

In particular we would like extend our thanks to Scientist Berit Jahnsen who organised the review process to become a pleasant and efficient event for the members of the review board.

## **7 THE EVALUATION ASSIGNMENT AND BOARD MEMBERS**

### **A The Evaluation**

1. The evaluation will include all activities at Division for Electronics, with the exception of basic research in upper atmosphere physics, which is presently being evaluated on the initiative of Norges forskningsråd, and activities in information warfare, which are in a start-up phase.
2. The aim of the evaluation is to provide advice to the Board on the quality of the work (against international standards), as well as its relevancy and value-for-money given user requirements and the overall mission of FFI. Where relevant, recommendations should be given.
3. The evaluation will be undertaken by a Committee of three, internationally recognised experts. The Committee's report – in English – should preferably be available for review by the board at its meeting in October 2000.

### **B The Committee will have the following members:**

Dr Kjell Arne Ingebrigtsen, Chairman  
Dr Viv Roper  
Dr Ole Petter Håkonsen

### **C Administrative Support will be given by FFI.**